BUREAU OF SUGAR EXPERIMENT STATIONS
BRISBANE

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CANE GROWERS'
QUARTERLY BULLETIN

ISSUED BY DIRECTION OF THE
HON. F. W. BULCOCK, MINISTER
FOR AGRICULTURE AND STOCK

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FOREWORD

EVERY year the Bureau of Sugar Experiment Stations expends several thousands of pounds in research and investigational work on behalf of the cane growers of the State. The scientific facts gathered in this way are of the greatest importance to the Industry, but our money and efforts are entirely wasted if we have no means of translating these facts into popular language and transmitting our statements to the growers for whom they are intended.

It has been our conviction that the methods hitherto employed in disseminating information leave much to be desired; and we are happy to announce that, in the future, a Cane Growers' Quarterly Bulletin will be issued, and transmitted directly to each individual grower.

In presenting this first number, we trust that farmers will appreciate our effort to provide them with the information they are seeking, and we take the liberty of suggesting that these serial publications be carefully preserved, for ready reference purposes as occasion demands.

H. W. KERR,

Director,
Bureau of Sugar Experiment Stations,
Brisbane.

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The
Cane Growers' Quarterly
—Bulletin—

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The Control of Sugar Cane Diseases.

By ARTHUR F. BELL.*

THE ultimate aim of all plant pathological investigations is the reduction or elimination of the economic losses caused by the diseases under consideration. Naturally, a very great deal of the work carried out has no immediate economic value but must be undertaken in order to advance knowledge to the stage where experiments having a direct economic bearing may be devised on a sound basis. This is particularly the case in Australia; our most important diseases have hitherto had a restricted distribution, and consequently we have not had the benefit of researches conducted in older sugar lands. The object of this paper is to set out for your information examples of the broad principles upon which we are working, and to indicate certain points at which we require the co-operation and support of a body such as this Society.

Apart from legislative measures in the establishment of various types of quarantine, the control of sugar cane diseases may be divided into three main modes of attack, as follows:—

1. Prevention, or what we might term escaping a disease, by the careful selection of disease-free planting material;
2. Reduction, either wholly or in part, of losses due to disease by modification of agricultural practices;
3. The breeding or introduction of suitable cane varieties which are resistant to the diseases of the locality.

The last-named is purely a matter for the plant breeder and pathologist, but, after the necessary knowledge has been obtained and disseminated, the application of the first two methods must rest mainly upon the efforts of the cane producer.

Disease control in countries where the estate system obtains, such as in Hawaii, and control in countries where the small farm system is the rule, such as in Australia, are two vastly different propositions, and the relative importance of the methods outlined above varies accordingly. The former are, naturally, in a much better position to combat diseases and their work is greatly simplified. For example, the estates, with unified control and command of finance, can easily place the important

* In a paper read in the course of proceedings of the Fourth Annual Conference of the Queensland Society of Sugar Cane Technologists, at Ayr (Q.), March, 1933.

factor of the selection and maintenance of supplies of disease-free planting material under the control of a specially trained technologist, and, of equal importance, can ensure that the conditions laid down by this man are fulfilled to the very letter. Again, we have a comparatively newly found disease in North Queensland, which, like Sereh disease in Java, appears to be readily controlled by hot water treatment of cuttings. In such treatments there must necessarily be rigid control of temperature, as a rise of 2 degrees would cause the death of cuttings, but it is a relatively simple matter for an estate to instal a plant to carry out the treatment effectively and expeditiously. On the other hand it is manifestly impracticable for the farmer to instal such a plant, and, similarly, the farmer cannot be expected to be an expert in the many phases of scientific agriculture. We do not criticise him for this; in view of the multiplicity of his activities it must be accepted as inevitable. But it must be emphasised that these and many other disabilities now attendant upon the farm system may be overcome by co-operation, and we urge it as the duty of members of this Society to stress the necessity for co-operative effort in agriculture and to foster its development as much as lies in their power.

PREVENTION.

The extent to which the practice of plant selection may be successfully employed will naturally depend upon the type of disease, the manner in which it is spread, and local conditions. In most parts of Queensland mosaic disease is very easily controlled by plant selection, but in a few restricted areas the rate of secondary spread is so rapid as to render this method useless, and recourse must be had to the use of highly resistant varieties.

The basic essential in the selection of disease-free planting material is the ability to recognise in the early stages any diseases which are likely to be encountered. Well illustrated pamphlets describing the symptoms of all the diseases found in Queensland have been published at various times and are re-published as occasion demands. Museum collections of preserved specimens have been established at various centres, officers of the Bureau disseminate information by lectures and visits to individual farmers, and as a later and important development a series of lectures on sugar cane diseases has been included in the curriculum of the sugar technology course of the Central Technical College.

When the symptoms are permanent and uniform, as in the case of mosaic and Fiji disease, it has proved quite easy to teach farmers to recognise these diseases, but it is unfortunate that many diseases, including our two most important, have symptoms which are frequently inconspicuous and transient, particularly in the early stages, and which vary a good deal in form throughout the life of the plant. In such cases it is almost impossible to obtain satisfactory diagnoses unless the observer has had special instruction and has been enabled to make first hand inspections of diseased plants in all stages.

While satisfactory plant selection may be made in the field in the presence of some diseases, the majority, owing to masking or inconspicuousness of early symptoms, require that plants shall be taken only from disease free fields. As an example of the latter type let us consider leaf-scald disease which may be found on practically every farm in the far North. Our investigations have proved that the symptoms of this

disease may remain masked for quite long periods, so that a series of very thorough inspections is necessary before a field can be declared disease-free. Fortunately, we are also finding that *in the absence of knife infection* the rate of secondary spread of this disease is for the most part very slow and, provided a field is planted with healthy plants and harvested with sterilised knives, the cane will remain healthy for reasonably long periods. We have every reason to believe that this and similar diseases may be controlled in all but the most highly susceptible varieties by the use of disease-free plants from small well-tended farm nursery plots which are in turn periodically replanted from isolation nursery plots.

Economic pressure bears yearly more heavily upon the cane sugar producer and has every indication of continuing so to do. It is rapidly becoming imperative even in the most favourably situated districts, to obtain the absolute maximum crop yield for a given monetary outlay, but maximum yields cannot be obtained when diseased and inferior cane is used for planting. We therefore submit the following scheme as the simplest method of ensuring satisfactory supplies of suitable planting material, particularly in tropical Queensland. A central authority, such as the management of a co-operative mill, should engage and equip a qualified man capable of conducting a disease control campaign. Under his supervision the central authority should purchase or lease a small area of land in an isolated position and cultivate up to about 10 acres of suitable cane. This small area could be inspected frequently and thoroughly cultivated in accordance with the best agricultural practice, and irrigated if necessary. Under the direction of the controlling officer the cane would be harvested and distributed to farmers for planting in farm nursery plots which would in turn supply the cane for commercial field plantings. These plots should be established on the farm as far from other cane as possible; they would not require to be more than an acre in extent, and so could be given the best care and attention, and precautions taken against accidental infection. As the chief precaution special knives would require to be kept for the harvesting of the nursery plot cane and cutting it into plants, these knives being sterilised periodically in boiling water or disinfectant.

The central isolated nursery plot should be practically self-supporting, and the expenses of the officer for the time spent in disease control would be small, since he could also be engaged upon pest control, agricultural experimentation, and other important and productive work. The direct expense to the average farmer through the purchase of plants might be as much as £1 per annum.

MODIFICATION OF AGRICULTURAL PRACTICE.

It is more or less a truism that any practice which will improve the vigour and vitality of the plant will also reduce the virulence of the disease, and in that respect improved agricultural conditions are a desirable aid in the control of any disease. At this juncture, however, we will consider only those diseases which are profoundly affected by modifications of cultural practice.

It is characteristic of the living organism that it lies heir to many ills of senility, and sugar cane is no exception. The obvious treatment for such diseases, then, is to harvest the cane before the advent of this period of senility, or, in other words, harvest the cane before it passes

beyond the point of maturity. Red rot and the sour rot of the Burdekin district may be considered as typical diseases of senility. Red rot is one of the most widely distributed of sugar cane diseases, and the causal fungus may be found with the greatest ease in practically every Queensland canefield. Therefore, in so far as this disease is concerned, plant selection is of little avail; we have found experimentally that red rot diseased cuttings germinate poorly, but such plants as do result are not more liable to contract the disease than are plants from healthy cuttings. The source of infection is ever present, and awaits only the suitable condition of the cane before launching its attack. The disease is rarely seen in immature cane, but once the cane attains maturity and begins to lose vitality the tissues are rapidly invaded by the fungus, the peculiar reddish rot results, and the sucrose content falls with alarming rapidity.

The solution of the difficulty is intimately associated with modification of our existing methods to the extent of instituting a rational maturity testing campaign, which will enable the date of the commencement of crushing to be determined by the stage of maturity of the cane and ensure that the individual fields are harvested at the most favourable time. Bad outbreaks of red rot may be taken as a symbol that either there is an undue preponderance of early or mid-season maturing canes or that the crushing season did not commence as early as it should have done.

Some modification of the above statement is necessary in the case of a very late maturing variety in the presence of droughty conditions during the later part of the season. In this case the unfavourable conditions may bring about a premature loss of vitality before the cane can attain maturity, and red rot is almost certain to make its appearance.

At the other end of the scale we have diseases which are greatly influenced by the time of planting as, for example, mosaic and red stripe (top rot) diseases. Mosaic is a virus disease transmitted from diseased to healthy plants by an aphid (*Aphis maidis*) which is most abundant in late summer and autumn. The cane plant becomes progressively less susceptible to mosaic with advancing age and, consequently, the older the plants are at the height of the aphid infestation the better chance they have of escaping the disease. In several countries, therefore, we find that part of the mosaic disease control programme consists in autumn planting. Red stripe disease, which is also known as "top rot" and "Burdekin top rot," is commonly found in Badila in North Queensland, and has come somewhat into prominence during the past few years. As in the case of red rot the causal organism is very widely distributed, and attacks susceptible varieties immediately conditions are favourable. So far our investigations have been confined mainly to Badila, since this is the only important commercial variety concerned as yet. We have found that in this variety the disease may be very simply controlled by the adjustment of the time of planting (or ratooning). Badila planted in March-May and given a good start off will be found to escape the disease, while immediately adjacent cane planted in the following spring may suffer a mortality of upwards of 25 per cent. during the succeeding January-March. As an interesting example of the efficacy of this form of control I would refer you to an experiment conducted at South Johnstone last year:—Two rows of Badila, one planted in April and the second in August, were planted side by side

in well-trenched ground, and as far as possible were grown under ideal conditions of moisture, drainage, and plant food supply. Throughout the period of growth no sign of top rot could be seen in the cane planted in April, whereas at the end of March death of stalks had occurred in the August plant cane to the extent of over 25 per cent. Some five or six years ago top rot in Badila was causing some concern in the Burdekin district, but in later years the amount has grown steadily less. This is no doubt due to the average earlier planting and the very considerable improvement in field practice which has taken place during the last five years.

Unfortunately, it is not always possible to practice autumn planting, or to harvest all the fields which are to be ratooned in early or mid-season, and we are faced with the problem of reducing the losses due to top rot in spring plant cane or late cut ratoons. At this point, however, it would be well to emphasise the fact that the losses from top rot are never as great as is popularly supposed, and a 10 per cent. death of stalks must not for a moment be taken as representing a 10 per cent loss of crop. We have conducted experiments which demonstrate that the loss of one or more stalks in the stool is compensated by the increased vigour of the remaining stalks in the stool. If the greater part of the death occurs moderately early in the rainy season it is probable that the death of as much as 10 per cent. of the stalks will cause a negligible loss of crop.

Statistical inquiries have so far confirmed our earlier observations on late-planted fields, viz., that the greater the number of stalks per acre the greater the likelihood of death due to top rot. In fertilizer trials the increased tonnages in the treated plots have been found to be due in part to the greater stalk production per acre, and the amount of top rot is likewise found to be somewhat greater than in the control plots. The increased amount of top rot in the Johnstone district during the past five or six years is therefore possibly due to increased use of fertilizers in late-planted crops during that period. It would seem then that the desideratum is the improvement of tonnages of late plant or ratoon crop by an increase in the size of the individual cane stalks rather than by increasing the number of stalks per acre, and this is one aspect of the problem now being investigated.

Cleanliness of the fields may be a very important consideration for two reasons:—(1) Certain weeds may be alternative hosts of the disease, and so act as sources of infection, thus largely nullifying the advantages of having used healthy planting material; (2) a disease may be transmitted by an insect which only feeds on cane by accident and would not breed on cane but which thrives on various types of weed. Both these factors operate in the case of mosaic disease, and thus control is greatly aided by clean fields and clean headlands.

A number of the organisms responsible for diseases are weak parasites, that is to say they are incapable of attacking a plant in full vigour, but should the host plant receive a set-back by adverse conditions, they become established and thereafter take toll of the host. The root diseases found in Queensland are of this type. They must be considered primarily as indicative of the existence of unfavourable conditions, and in the absence of drought are controllable by improvements in planting material, fertilization, or cultural conditions.

BREEDING OR INTRODUCTION OF RESISTANT VARIETIES.

In the absence of the estate system and in the absence of a co-operative and co-ordinated agricultural policy, the development of resistant varieties must constitute the chief mode of attack in the control of cane diseases in Queensland. This method has the advantages of being permanent, automatic in operation, and imposing no direct expense—in short, something for nothing—and thus in full accord with the commonly held view that disease control is something that should entail neither time, labour, thought, nor expense. The disadvantages lie in the fact that the original search for resistant varieties is often a slow, tedious business, and many excellent varieties of superior yielding power must be discarded through not quite attaining a fool-proof standard of resistance. Of course, circumstances may permit of no choice of methods, and in the Southern districts, where the rapidly transmissible gumming disease is so widely distributed, we must have recourse to highly resistant varieties at least until the situation has improved very considerably.

Up to the present our chief efforts have been directed towards finding varieties resistant to gumming disease, and a description of the methods used will serve to illustrate the principles as applied to other diseases. During the conduct of resistance trials it has been observed that the progeny of particular crosses could be readily classified according to the general standard of resistance exhibited. For example, it would be found that the progeny of the cross A x B contained a high proportion of resistant seedlings, while the majority of the seedlings from the cross C x D proved highly susceptible. Accordingly, our disease-resistance trials are now of two types:—

(*a*) About two stools each, of up to 100 selected seedlings representing each new cross to determine whether or not the particular cross has a reasonably good chance of yielding disease-resistant seedlings. If only a very low proportion of resistant seedlings are produced the cross is naturally discarded.

(*b*) Six to ten stools of seedlings which show commercial promise or varieties which have been imported from abroad.

The trials are carried out in a locality where conditions are favourable to the full development of the disease. Included in each trial are several varieties of graded resistance or susceptibility whose performance under field conditions is well known, and the resistance of the unknown varieties is then determined by reference to these known standards. Every second or third row in the plot is a guard row consisting of a mixed planting of susceptible varieties, so that every unknown variety is in contact with guard row cane of two or more varieties. When the cane is 2-3 feet high the plants in the guard rows are inoculated by means of needles dipped into a suspension of the gum. This susceptible cane soon develops the disease, and thereafter serves as a constant source of infection for the experimental varieties. Inspections are made periodically, and the progress of the disease in each variety is recorded and, at the conclusion of the trial, all doubtful canes are dissected and examined. The results obtained are clear cut and remarkably consistent, and in most cases there need be little hesitation in accepting the results of a single trial with any one variety. The effects on the cane vary to

a remarkable degree, ranging all the way from the practical immunity of Uba to a consistent 95-100 per cent. death in the case of the seedling S.J.4.

In order to find varieties to combat gumming disease, about 80 selected varieties were imported from Hawaii, India, and Java in 1928-9, and after growing in quarantine for a year were planted in resistance trials in 1929 and 1930, together with fifty to sixty varieties which were already in the country. As a result of such trials we have found some fifteen varieties of sufficiently high resistance to be grown in the presence of gumming disease with impunity. Some of these are now in a yield trial, and the remainder are being propagated for inclusion in yield trials as soon as possible. Some of these canes show considerable promise, and it is confidently expected that they will be the means of eliminating all losses due to gumming disease in Southern Queensland.

Gumming disease lends itself to this type of investigation rather more than most diseases, but the principles are gradually being applied to other important diseases, of which leaf-scald is now receiving chief attention.

Experiments in Grub Control in the Lower Burdekin District.

THE possibility of controlling the Northern cane grub by means of the application of white arsenic to the soil received attention from officers of the Entomological staff of this Bureau some years ago. The results obtained from experiments were not very encouraging, and further trials with this poison were abandoned. In the Lower Burdekin district, however, where grub infestation is usually too light to warrant the expense of fumigation, the use of this method has been continued by a number of farmers, particularly in the Giru area. Owing to a very great increase in the numbers of grubs in the district this year, this mode of treatment has been more widely used than previously; consequently, it was deemed advisable to obtain definite experimental evidence as to the value or otherwise of arsenic for controlling the grubs under the conditions prevailing in this district.

A visit was paid to the district in May by Mr. J. H. Buzacott, Assistant Entomologist, and after a preliminary survey of suitable sites, Mr. Buzacott set out six field trials. In these trials, dressings of 80 and 200 lb. of arsenic per acre were applied by sprinkling over the drills after planting, but before the germination of the cane. There are four replications of each treatment in each experiment. The progress of these trials will be carefully watched throughout the year, and in addition the results, if any, will be checked against those obtained by fumigation with carbon-disulphide early in 1934. Five of the trials were set out in the Giru area, and one at Rita Island.

A New Implement—The Stubble Shaver.

By H. W. Kerr.

THE comparatively unsatisfactory nature of ratoon crops in Queensland is appreciated by most canegrowers. This is particularly true for the drier areas of the State, and the irrigated Burdekin district is included in this class. Undoubtedly there are a number of causes contributing to this effect, and one of particular interest is the difficulty of keeping the stools well set in the ground. Any practice which encourages the growth of the stool in the dry surface layer of the soil will act detrimentally to the production of good ratoons. This is especially noticeable where irrigation methods involve the practice of hilling-up. In such cases it is desirable that the land surface be levelled down at ratooning time, and the development of the ratoon shoots from the bottom eyes of the stubble encouraged. Those growers in the Burdekin area who are producing profitable ratoon crops pay particular attention to this point.

Even where "level" cultivation is practised, the benefits which followed the destruction of the top eyes of the stubble are reflected in the resulting ratoons. The need for a suitable implement to enable this operation to be effected expeditiously and satisfactorily has been keenly felt, and it is appreciated that the bumper disc harrows are only partially successful in their work in this connection.

It is pleasing to announce, therefore, that an implement especially designed for the purpose has recently been imported to Queensland. It comes through the courtesy of the Onomea Sugar Company of Hawaii, who designed the implement for use on their plantations, where its results were entirely satisfactory. This "Stubble Shaver" as it is called, is being despatched to the Burdekin district, where it will be thoroughly tried out. Later, it will be transferred in turn to the chief cane districts of the State, and growers will be afforded an opportunity of studying the machine and its work.

The accompanying photograph (Fig. 1) shows clearly the essential features of the implement. It is mounted on four wheels, which is a decided advantage on land of uneven surface as it allows for better control of the cutting discs. These latter are revolved about a vertical axis by a chain drive from the rear axle. The drive is thus transmitted from the two rear wheels and should ensure positive action. The discs are each 24 in. in diameter, and the depth at which they work is readily controllable by the operator, through the lever provided. In this way satisfactory work may be done on fields where the stubble is set at irregular heights or the land surface is uneven. Further, the depth below the surface at which the shaving is done will depend on the nature of the stools, which again is a function of the variety and cultural practices, as well as the soil and the nature of the crop harvested.

The implement is designed for draught by a light tractor, but it could also be adapted for horse work.

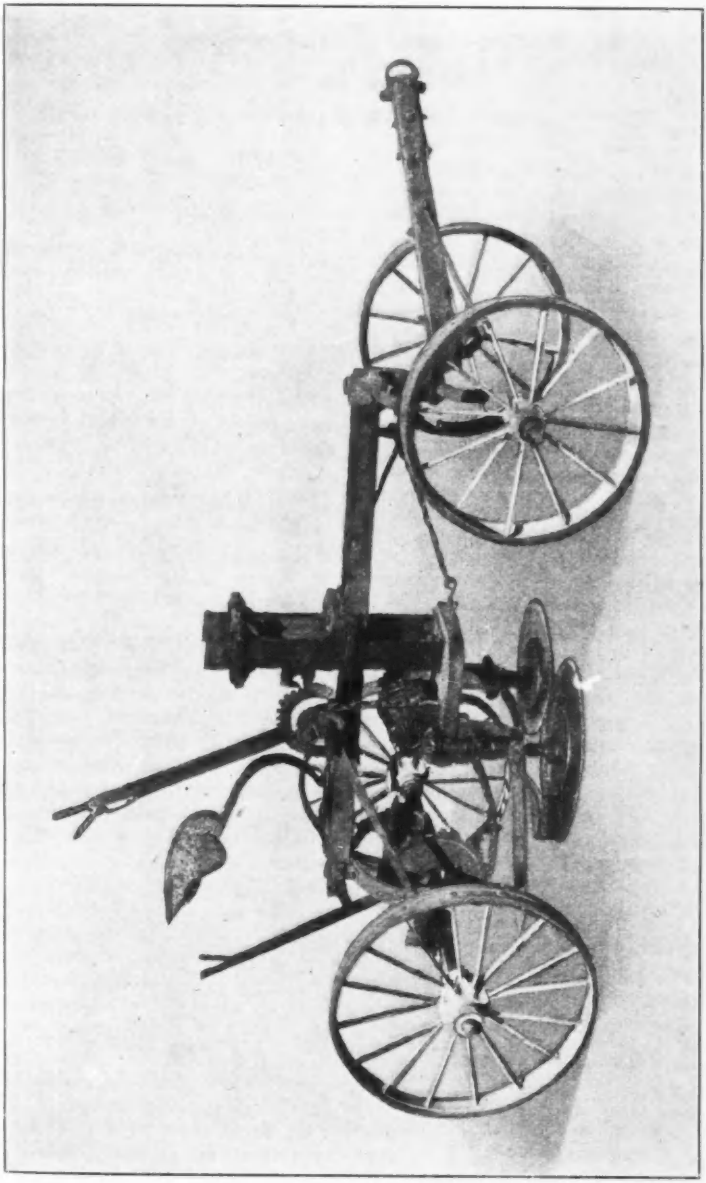

FIG. 1.—THE STUBBLE SHAVER.

Irrigation Principles.

By H. W. Kerr.*

RECENT events indicate that our sugar industry is again entering one of those troublous periods with which its history is punctuated. The present situation is largely the result of depressed times following closely on the heels of a few years of relative prosperity which saw a tremendous expansion in the area devoted to the crop. A sudden contraction in the price of locally consumed sugar, coupled with a collapse of world market values for the surplus production have created a situation which will inevitably inflict many hardships on the producer before the necessary adjustments may be made. Little hope can be held out for an improvement in the Australian price, while even the most optimistic would not hazard the forecast of an immediate recovery in world values to a level which would make it possible for the Queensland producer to compete profitably on the open market. Stability will be restored then, largely as a result of decreased production costs, and it is this aspect of the problem which will be discussed in the present paper.

In the ensuing struggle, the grower is undoubtedly faced with the most profound difficulties; and this is particularly true of the "small" farmer who employs but little labour, and to whom reduced sugar values mean a severe contraction in the family income. Any reduction in production costs, as far as he is concerned, must come entirely as a result of individual initiative, and a modification of present farming methods to ensure a return which will more than cover cultivation costs. This will be particularly difficult in those areas where a combination of depleted soils and uncertain seasons conspire to make farming a hazardous undertaking; and a careful review of the situation shows clearly that no single factor will contribute more to a successful reconstruction than to place the business of cane growing beyond the reach of climatic vagaries. A growing realisation of the truth of this observation is clearly evident throughout the central and southern areas, and one is led to the conclusion that the dawn of extensive irrigation farming is at hand.

Those members of our agricultural section who are privileged to attend the present Conference will be afforded an excellent opportunity of seeing what can be done by the judicious application of water, to enable the cane crop to maintain steady growth through those drought periods common to all cane areas. Growers in the Ayr district early realised the absolute necessity for irrigation if their lands were to realise the high productivity which their natural fertility promised. They are, therefore, able to point proudly to the distinction which their district enjoys of maintaining the highest average production of sugar per acre in Queensland. It should be clearly understood, however, that it is only during the past few years that farmers in this area have realised that keeping the crop alive by irrigation, in anticipation of the wet season's rain, is not a profitable undertaking, and results rather in an increase in production costs. Hence it will be observed that leading

* In a paper read at the Fourth Annual Conference of the Queensland Society of Sugar Cane Technologists, Ayr (Q.), March, 1933.

growers have turned their attention to the maintenance of vigorous growth by artificially applied water, and their results promise to revolutionise farm practice in the area.

This latter fact is emphasised to clear up a point which many growers are inclined to advance as a serious objection to irrigation proposals; they argue that if the added cost of irrigation will guarantee an average yield of only 20-25 tons of cane per acre, no reduction in the cost of producing a ton of cane will be effected. But on studying the returns from those farms of the district where cane is literally grown by irrigation, assisted, of course, by the application of the necessary fertilizer, it will be found that the average yield is nearer 40-45 tons per acre. Further, these returns are generally independent of the season, while the profitable increase shown from the use of artificial manures makes it possible to maintain soil fertility and thus preserve the productivity of the land. Though the latter aspect of the agricultural problem is one which our farmers would gladly forget in times of adversity, it is nevertheless true that past failure to appreciate the importance of maintaining the "working capital" of the land—its fertility—is probably contributing as much to the present reduced crops as the absence of favourable climatic conditions.

A second objection which is often raised against irrigation proposals is that of the difficulty of financing the scheme. It is agreed that this problem is a real one in many cases; but it is remarkable how many enterprising farmers have been able to provide themselves with a satisfactory water supply at very little cost. The success of the venture generally provides the means for installing more adequate equipment in the course of a few years.

Although these preliminary remarks might appear to be addressed chiefly to growers who are farming in the central and southern districts, it must be emphasised that they apply with equal force to those who are producing cane in the northern areas also, where nature is more liberal in the bestowal of her favours. During the past year a small scale irrigation trial was conducted at the South Johnstone Experiment Station, under conditions which were made as nearly as possible ideal for cane growing. It was found that the natural rainfall distribution of even the Innisfail district is quite incapable of maintaining steady cane growth, and the irrigation water applied during the growing season resulted in a tremendous increase in crop yield. Truly, the conditions of the trial referred to are not capable of realisation in farm practice, and therefore the yield per acre as calculated on the basis of the produce from this small plot (144 tons of cane per acre) is quite fictitious. But even a yield of one-half this value would be greatly in excess of the normal plant crops which are harvested from lands of this type under first-class farming methods. Considering the facilities which are so admirable for irrigation on large areas of the far North, it is most surprising that in no instance has the writer seen any pretence at exploiting these natural resources.

IRRIGATION PROBLEMS.

For the benefit of those who are seriously considering the development of such irrigation facilities as are at their command, a few of the important inherent difficulties of irrigation practice will be pointed out, and suggestions offered for obviating such as may be

avoided. First of all, it must be realised that irrigation water differs, in general, from natural precipitation. The latter is essentially nature's own pure distilled water, until the moment it reaches the surface of the earth. Thence the surplus moisture either runs off and finds its way into natural watercourses or percolates into the depths of the porous sub-soil strata, where it may again be tapped and brought back to the surface by artificial means. The latter method provides the bulk of the irrigation water employed in the Burdekin area. Now, in the course of its passage over or through the earth, the original pure water exerts a greater or lesser solvent action on the mineral particles with which is comes in contact. It is found, moreover, that certain substances which are dissolved in this way possess properties which may render the water distinctly unsuitable for irrigation purposes, and therefore, the *quality* of the water which it is proposed to employ should first of all be determined. Of these contaminating compounds, the chief are excessive amounts of salt, and carbonate of soda. The upper limit of the concentrations of each of these substances which may be present without producing harmful effects is a matter which can be decided only after due regard has been paid to the nature of the soil on which it will be employed. When impure waters are employed, certain irrigated soils show a pronounced tendency to develop unfavourable sticky characteristics, which after a time make it very difficult to produce and maintain a condition of good tilth. In such cases the proportion of the above impurities which may be tolerated is decidedly low. On the other hand, the red volcanic soils possess the peculiar property that concentrations of even a hundred grains or more of salt per gallon may be present in the irrigation water without effecting serious damage. Of course, it must be remembered that the accumulation of salt in the soil moisture will ultimately inhibit growth due to the inability of the plant roots to absorb water under these conditions; and where the water employed is rich in salts, care must be exercised to provide for adequate subdrainage, which will enable the soluble salt to be washed from the soil. Carbonate of soda is a particularly troublesome substance, for in concentrations of even a few grains per gallon it acts as a definite plant poison, while its effects on the soil are cumulative, and definite steps must be taken to neutralize this influence. Fortunately, this consideration of water quality may be readily cleared up by an analysis, which will be conducted free of charge for canegrowers by the Bureau. The water from our coastal streams is usually of high quality, except where tidal influences prevail; and growers can be reasonably assured that such sources will be entirely satisfactory for irrigation purposes.

Adequacy of Supply.

The next consideration is that of the volume of available water. On more than one occasion the water-loving characteristics of sugarcane have been emphasised. The growth of a 40-ton crop involves the absorption of practically 50-55 acre-inches of water from the soil; when allowance is made for the fact that much of the rain which falls on the land in times of heavy downpour is lost by surface run-off, a further proportion is removed from the range of the crop roots by deep percolation, and appreciable quantities are lost by evaporation from the moist land surface, probably not less than 100 acre-inches of moisture are utilised or dissipated in the process. Where

cane irrigation is contemplated in the drier areas of our State, it may be assumed that at least 40 acre-inches of water will be applied artificially per annum. In round numbers, this means 1,000,000 gallons of water per acre; or, for 40 acres of cultivation, 40 million gallons. Carrying the calculation a little further, let it be assumed that this volume of water will be applied over a period of 100 days. The average daily consumption will then be 400,000 gallons. These figures will show that it is extremely important to have access to an adequate supply of water before the project is embarked on. Where a small open flow is being drawn upon for the supply, a further important point must be observed. October and November are probably the two months of the year when irrigation water will be in greatest demand. In Queensland the spring is usually the driest period of the growing season, and, by the same token, the flow of water in natural watercourses is at its lowest ebb. In making a survey of streams of limited capacity it should, therefore, be remembered that estimates of supply must be made at this season.

Distribution of Water.

Assuming that an adequate volume of water is available, the next consideration is the problem of its application. When natural rainfall is received by the land, the even distribution of the water is automatically taken care of; but when water is applied artificially considerable skill must be exercised in this regard. Irregularities in the land surface are frequently present to complicate the problem, and even under the most favourable circumstances the supply of water to the margin of the field where the water enters is inevitably greater than at the distant end of the water furrows. For the former problem something may be effected by judicious grading, but this is a project which must be undertaken only with the greatest care. Where the soil is shallow, the removal of even an inch or two of the surface layer might be decidedly detrimental to the fertility of the land; and grading may be effected successfully only where a good depth of surface soil is available. To prevent gross irregularities in the distribution of water as between opposite ends of a field, the remedy is to restrict the length of water furrows. The mistake is still made in some cases of attempting to run the furrows for 15 chains or more; and under these conditions it will be found that whereas the near border of the field may receive 12 inches at one watering, the distant end may get less than two. Not only does this result in a tremendous wastage of water, with the consequent addition to irrigation costs, but the danger of water-logging the soil where sub-drainage is not highly favourable may cause serious injury to both soil and crop. Where water costs are relatively low, it is considered that to effect a saving in labour by this method, is sound economy; but the wisdom of the policy is highly hypothetical.

Employment of short furrows—say, from 3 to 5 chains—will undoubtedly lead to increased demands on labour; but it is felt that careful comparison of the respective methods and the results obtained will show that the shorter furrow system is superior. The water saving which will be effected and the consequently increased speed with which the entire farm may be irrigated, will probably outweigh any advantages offered by the alternative system, without reckoning any increased value for the superior crops produced. When

pumping costs are relatively high—for example, where deep wells are employed or where the water must be raised above a high river bank—the above-mentioned conditions might be entirely reversed, and it will pay the farmer better to increase his labour costs to enable a given supply of water to be spread over a larger area.

Need for Sub-drainage.

The danger of water-logging any soil devoted to cane-growing has been repeatedly emphasised; and under irrigation practice where the water contains a proportion of dissolved salts, the damage done is much more serious than with natural rainfall. If free sub-drainage is not provided, the accumulation of soil moisture which is slowly evaporated both by the crop and from the soil surface, may lead to a serious concentration of salt. It has already been pointed out that the crop is critically injured under these conditions.

Where the sub-soil contains a reasonable proportion of clay—and this is usually the case under conditions of poor drainage—the mole drainer may often be used to advantage. It obviates the excessive cost of tiles, which are practically the only alternative. The necessity for paying detailed attention to soil drainage is especially important for an area such as Mackay, where the alluvial lands are practically level, and of these the older types of soil possess naturally an impervious sandy clay sub-soil layer frequently associated with ironstone nodules.

Frequency of Watering and Amount Applied.

One of the most important questions in irrigation practice is that of the frequency of water applications and the amount of water which should be applied at one irrigation. At the present time in Queensland, irrigation must be considered essentially as an *art*, in that the farmer is guided mainly by intuition in determining when a further watering is called for, and also in judging the volume which should be applied. Obviously it is highly desirable that the practice of irrigation be placed on a sound *scientific* basis. Extensive researches in this connection have been undertaken in overseas cane countries, and some of the more recent results are extremely interesting and valuable.

First of all, we should be able to determine definitely the point at which active crop growth ceases due to soil moisture deficiency. The method of carrying out this work is by making systematic growth measurements on selected cane stalks, at frequent intervals following an application of water. Where the results show that growth has practically ceased, a sample of soil representative of the area under review is taken and its moisture content determined. It is a well established fact that a given soil is capable of holding a definite percentage of moisture in its natural thoroughly-drained state in the field. Of the water held in this way, only a fixed proportion is available for the maintenance of vigorous growth, and tests show that the amount of moisture still present in the soil when growth ceases is quite appreciable. This point must be definitely understood if one of the fundamental principles of irrigation practice is to be clearly grasped. As an illustration of the order of moisture percentages measured in this way, a series of studies carried out on a red volcanic soil might be taken. The results show that this soil retains as a maximum 32 per cent. of its weight of moisture after draining,

and when the growth rate of its crop falls to a minimum, it still contains 20 per cent,; that is, moisture equal to only 12 per cent. of the weight of soil is available for the maintenance of vigorous cane growth. It is generally conceded that the crop draws the bulk of its moisture from the uppermost 3 feet of soil, and obviously the distribution of roots in this layer is not so uniform that all portions of the soil will be dried out at the same rate. A typical series of moisture studies is the following:—

1st foot of soil—22 per cent. moisture

2nd foot of soil—25 per cent. moisture.

3rd foot of soil—28 per cent. moisture.

It is now quite a simple matter to calculate the amount of water which should be applied to bring the soil back to a uniform moisture content of 32 per cent. From the above data it is found that a 3-inch irrigation would restore this particular soil exactly to that condition, while allowing no excess water to be lost by deep percolation.

The problem is not quite so simple as the foregoing remarks would indicate, and so far as the determination of the soil moisture characteristics is concerned, an extensive series of tedious tests is involved. Once the work has been completed, however, the knowledge gained is of immense value to the grower.

Nothing has been said as yet regarding the rate at which the soil loses its moisture. It is found that this factor is governed principally by (*a*) the stage of development of the crop, (*b*) the season of the year. A young plant with its restricted root and leaf development will obviously not utilise water as vigorously as one which has attained its peak of leafy growth supported by a root system which thoroughly permeates the soil. Again, temperature considerations are very important in determining the rate of crop growth, and consequently the rate of water consumption. The problem is further complicated by such factors as the degree of atmospheric humidity, incidence of winds, the soil type itself, and the same considerations also govern the rate of moisture loss by direct evaporation from the soil surface. As an instance, it might be pointed out that in the early summer months the Ayr district usually experiences high temperatures associated with strong, dry winds. Under these conditions the rate of water consumption by the crop is excessive, and the unfavourable atmospheric conditions are so distressing to the cane plant that crop growth is severely hampered. At the corresponding season in the more humid north, the rate of growth is phenomenal where soil moisture is available (see Fig. 2).

As a general rule, however, it may be assumed that a young crop requires rather infrequent light waterings, while a well advanced crop will respond to heavy irrigations at ten-day intervals during the height of the growing season. It is a well established irrigation principle that at the time of planting any crop, it should be the aim of the grower to have his soil at the so-called "optimum" moisture content, and *defer* irrigation until the crop is definitely showing symptoms of soil moisture deficiency. From the time irrigation is begun, the development of the crop should be continued uninterruptedly throughout its lifetime. Serious growth checks act highly detrimentally to crop yields, and add materially to production costs.

Time of Planting.

In attempting to follow this principle, it is obvious that the planting season will be important. Remembering again that the spring months are so frequently dry, autumn planting would appear to be most favourable in this respect. In point of fact, it has been found by experience in the Burdekin area that March-April planting usually yields the most favourable results. There is a further point which requires stressing in favour of this policy, and one which is not often appreciated. When the cane sett is planted, it yields, first of all, a primary shoot which in the course of time gives rise to secondary (and possibly tertiary) shoots which originate from the base of the original parent. This "stooling" process, as it is known, is essentially a slow one, due to the limited leaf surface of the young crop, and consequently its restricted capacity for the production of sugars and other foods essential for growth. Seeing that this stage is necessarily one of slow development, the question arises—what are the relative rates at which it proceeds for autumn and spring planted crops? Obviously, the former will be passing through this stage during the autumn, winter, and early spring months, while the latter will utilise the spring and early summer months for the purpose.

Some interesting facts in this regard are afforded by the small irrigation trial carried out at South Johnstone. The growth rate measurements which were made on this crop at three-day intervals showed that the April planted cane germinated more rapidly and maintained its early growth at a greater rate than that for the August planted cane, for a period of about ten weeks after planting. Thereafter the August plant cane showed an accelerated growth rate, and at exactly five months after planting the two crops showed the same stage of development. That is, the April crop had attained this point in September, while the later crop had not attained its peak of leaf development until January. As a result, the former showed millable cane in November, and during the month of December, with its long, hot days, showed a greater rate of cane production than during any other period of its life. This point is clearly shown in the diagram for the April plant (Fig. 1). The spring planted crop, on the other hand, did not produce millable cane until mid-January, and the more favourable early summer months were entirely lost in this respect.

Under the climatic factors which prevailed for that particular year, at least, there can be no doubt that the autumn planted crop was vastly superior to that which was planted in the spring, provided soil moisture conditions were at all times favourable. It is probable that similar results would also be experienced in most of the cane areas of the State under adequate irrigation, with the exception that in the southern districts February-March planting would be substituted for April. Modification of the plan would be necessary, of course, if excessive rainfall during these months were to render planting impracticable.

Position of Water Furrows.

The position occupied by the water furrow is a matter of considerable importance. It is the usual practice in the Burdekin area to utilise the planting drill for the purpose, so long as this is available. But the light cultivation which is essential, after watering,

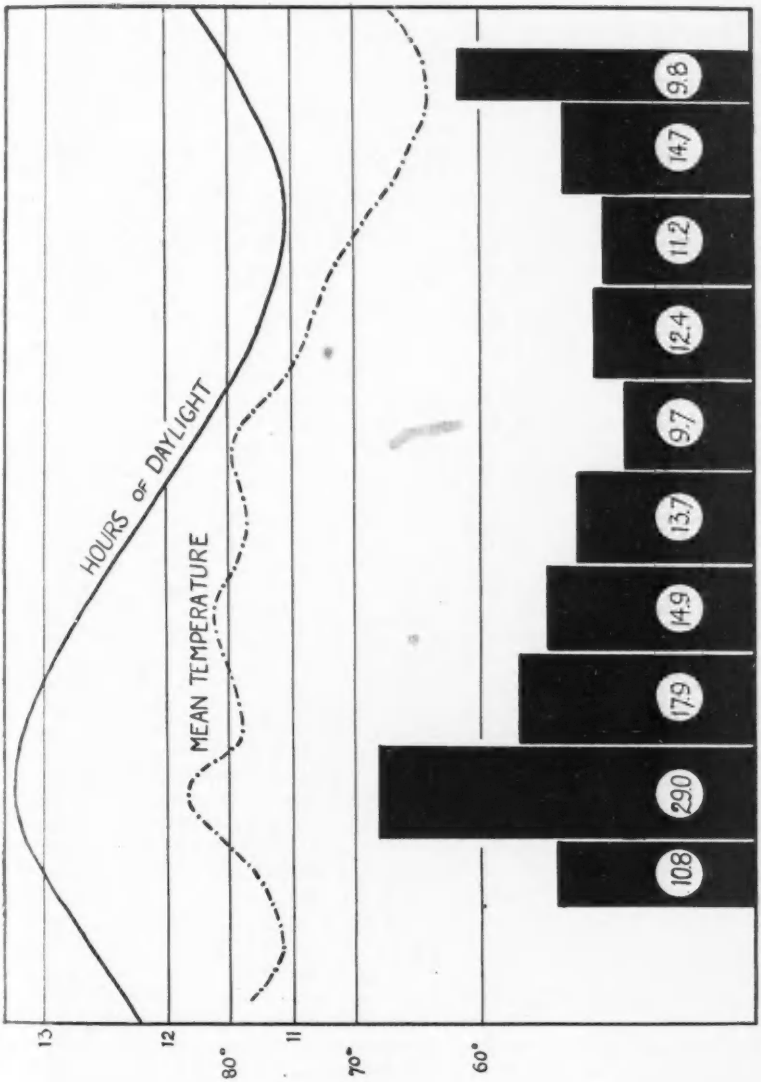

FIG. 2.

The solid blocks represent the tons of cane per acre produced under optimum conditions during each calendar month. The curves for hours of daylight and mean temperature fit very well with the growth rate, and show the particularly favourable growth conditions of December, provided that moisture and plant food are available.

to restore the good tilth of the soil, control weeds, and create a surface mulch, results in a filling of the cane drill. This is often accelerated, in fact, in order to smother the heavy weed growth in the drill and avoid costly chipping. Thereafter, special water furrows are prepared prior to each watering. These are run at varying distances from the cane, but usually occupy the middle of the interspace. This is, undoubtedly not in the best interest of economical utilisation of water. For to bring about a complete wetting of the soil mass occupied by the cane roots—and this area spreads in the form of a cone below the sett—it is assumed that lateral water movement will be effective. That this movement is slow and incomplete is a well established fact, and the desired result may be realised only by the application of excessive amounts of water, with the attendant difficulties already discussed.

Ratooning Problems.

Undoubtedly, this is a problem which deserves closer study, and every effort should be made to keep the cane furrow open as long as possible. Interspace water furrows also result in the hilling up of the cane, which, though not detrimental to the yield of the plant crop, introduces a serious obstacle to successful ratooning. The fact that so few profitable ratoon crops were produced in this area for many years provides definite evidence of the weaknesses of the prevailing practice. Recently, however, the ratooning problem has been attacked with a considerable measure of success. It was found that to produce heavy first ratoon crops it is necessary to make an application of water and fertilizer to the stools as soon as possible after harvesting the plant crop. To get the water to the stool and also to ensure that the ratoon shoots will be well set in the ground instead of on the surface of the dry hill, the first step taken is to level the field down by the use of bumper disc harrows, or sometimes the rotary hoe. Probably a suitably constructed stubble shaver would be even more effective. Naturally, the ratoons will need irrigation and cultivation just as much as did the plant crop, and with respect to fertilizer applications, considerably more so. In the Burdekin area, it has been demonstrated conclusively that heavy dressings of sulphate of ammonia have a profound influence on ratoon yields; while in other areas, where the soils are not so richly provided with available phosphates and potash as are these, heavy applications of general manures will be necessary in addition.

In this connection it must be emphasised that irrigation alone will not ensure satisfactory crops on depleted soils. Plant food and water are equally instrumental, and, indeed, with the harvesting of the heavier crops which will naturally be sought, this point is of paramount importance. As a general guide it may be assumed that to replace the plant food removed from the soil by 1 ton of cane, about 25 lb. of mixed fertilizer must be applied to the land. Thus a 40-ton crop robs the soil of the equivalent of 1,000 lb. of fertilizer per acre, and few, if any, of our cane lands are capable of standing up to this treatment for any period of years without suffering a tremendous reduction in their fertility and productivity.

In passing, it should be mentioned that a recent innovation in ratooning procedure in the Ayr district appears to offer a simple and effective method of ratoon irrigation which will be highly economical on water. This is a most important aspect of the problem for in general

the pumping plants which are in operation are not competent to deliver the water necessary at peak periods to enable both plant cane and ratoons to receive the full supply they require, *when* they require it. The essentials of the method are as follows:—

The initial discing is carried out as outlined above, and the early waterings are given in the usual manner, by creating the customary interspace water furrows. With subsequent cultivation a certain amount of "hilling up" is inevitably brought about; but prior to the last watering after which the crop will be out of hand, a 10-inch swing plough is used to produce a furrow about 6 inches deep, close to one side of the cane row. This operation is usually completed in December, and thereafter this is employed as the watter furrow, no subsequent cultivation being given. The essential effects of the operation are shown by the accompanying sketches (Fig. 3).

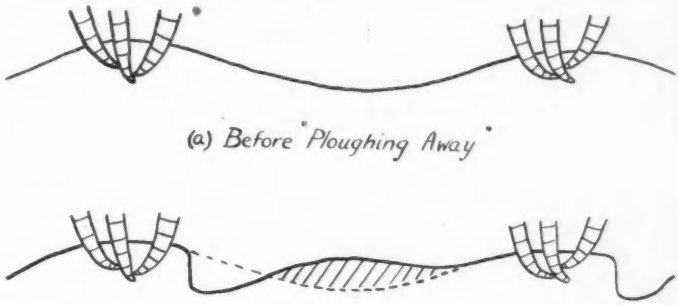

FIG. 3.

To facilitate tramming, each twentieth line remains untreated.

The advantages claimed for the method are that cane covers in much more rapidly than is the case with the customary practice, probably due to the fact that the water is applied in closer proximity to the point where it is required. For the same reason, the policy is more economical on water, and this enables an irrigation round to be completed in quicker time. Finally, excessive flooding is avoided, so that much of the soil surface remains dry, it retains its condition of good tilth, evaporation losses are reduced, and weed growth is inhibited. The modification should certainly appeal to canegrowers practising irrigation, and the final verdict on its practicability will be awaited with interest.

Conclusion.

So much for a brief outline of certain of the fundamental principles of irrigation. Undoubtedly numerous other questions are in the grower's mind, particularly those on the practical side regarding the installation of suitable equipment, laying out of main supply ditches and laterals, the utilisation of fluming, and so forth. While regretting that this aspect of the problem cannot be dealt with at present, it should be added that there is no better way of acquiring information on these important considerations than by visiting the Burdekin area. Here visitors may be assured that every assistance will be afforded them in obviating many of the practical errors into which pioneers in this field are inevitably drawn.

The Spread of Fiji Disease by Insects.

By R. W. Mungomery and Arthur F. Bell.

FIJI disease is the name given to a serious disease of sugar cane which was found in Fiji some thirty years ago, but the disease has since been found in New Guinea, and it seems likely that it originated in the latter country. Fortunately, Fiji disease is not found over a great area of the sugar districts of Queensland, and it behoves growers to restrict the further spread by conscientiously refraining from taking plants from one district to another unless the Bureau has certified to the health of the cane. Our experiments have shown that this disease may be present in a stool for some months before symptoms develop, and consequently in an area where the disease exists, it is impossible to be certain that any particular stalk is perfectly healthy in spite of its favourable appearance. The disease is widespread in the Maryborough and Beenleigh districts, and has been found on about twenty-five farms in the Bundaberg area, and on about a dozen in the Moreton area.

Heretofore the rate of spread of Fiji disease in Queensland has been slow, but recent experience in Fiji proved conclusively that the rate may be very greatly increased when the balances of nature are upset. In addition, it had been noted that some of the very promising new varieties of cane, which had been introduced to control the gumming disease situation, were far more susceptible to Fiji disease than our present standard canes. In view of this information, it became obvious that a knowledge of the manner in which this disease was spread in the field was urgently required so that we might conduct disease resistance trials, and also possibly find some method of reducing the rate of spread.

From the general characteristics of the disease we considered it likely that it would prove to be spread from plant to plant by an insect, in much the same way as malaria is carried from one human being to another by the mosquito. Accordingly, we commenced experiments in which diseased and healthy cane was grown under insect-proof calico cages and various types of insect placed in the cages, so that they would feed on the diseased and healthy cane. As a result of these experiments, and further confirmatory trials in open plots, it was found that the disease was spread from plant to plant by the cane leaf-hopper, which is known scientifically as *Perkinsiella saccharicida*. Upwards of one dozen types of insect commonly found in cane fields and headlands were investigated, but the leaf-hopper was the only one with which positive results were obtained.

The leaf-hopper is a small active greyish-brown insect between $\frac{1}{5}$ and $\frac{1}{4}$ in. long. It is most frequently found feeding around the base of the central spindle of folded leaves; when disturbed, it usually moves round to the other side of the plant, but if persistently molested it will make a sudden leap or hop into the air, and then alight on a nearby cane stool. Thirty years ago leaf-hoppers, which had gained entry into Hawaii through the introduction of new cane varieties, became a serious menace to the sugar industry there, but were soon controlled by the importation of parasites from Australia and elsewhere. In Queensland they are controlled by a number of other insects which are parasites

FIG. 4.

Stiff, stunted, and malformed leaves typical of a well-advanced stage of secondary infection. The general appearance is suggestive of the upper portion of the leaves having been bitten off by some animal. Variety E.K.1.

upon the hopper or its eggs, and have never been a serious pest in sugar cane, but of course they now assume a new importance since we have found that they transmit Fiji disease. The egg parasites are very fragile insects, and are killed in vast numbers by heavy cyclonic rains; consequently, the leaf-hoppers are very likely to increase following a prolonged and heavy wet season—as has happened in Fiji.

Now that the means by which the disease is spread from plant to plant is known, it will be possible to plan resistance trials so that we may know in advance whether a variety is likely to prove susceptible or resistant to the disease. In addition, attention will be given to the question of possibly reducing the numbers of these insects in the cane-field, and hence reducing the rate of spread. Field counts of leaf-hoppers have demonstrated that these insects do not normally become numerous until January, and so it is highly important that all diseased stools of cane should be destroyed early in the spring, and not allowed to remain in the field until this increase in the number of hoppers takes place. We have also found that the number of hoppers present in a field depends to a great extent upon the vigour of the crop; with irrigated crops or crops grown on river flat lands the numbers are much greater than is the case with the poorer crops grown under less favourable conditions. As a natural result, the rate of spread is much more rapid in the irrigated and river flat cane, and in such areas control cannot be satisfactorily effected unless plantings are made with absolutely disease-free material. Furthermore, since our experiments have demonstrated that the symptoms of the disease may be masked for several months, at least during the winter period, plant selection should not be based upon a single inspection.

No difficulty should be experienced in recognising the disease in the field. When a growing stalk becomes infected with the disease in an active form, all further upward growth ceases, the leaves become greatly stunted and stand out stiffly from the crown, while the younger leaves tend to curl inwards and develop brownish scalded margins. The general appearance is such as would be produced if some animal had bitten off the tops of the young leaves before they unfolded, and is well illustrated in Fig. 4. The identity of the disease is definitely settled by the finding of small galls on the veins on the under surface of the leaves; these galls are usually about ¼ to ½ in. long and 1/32 to ⅛ in. in diameter, but may be up to several inches long. They may perhaps best be described by stating that they have the appearance of varicose veins. When a diseased cutting is planted, or a diseased stool ratooned, no millable cane is produced, but the resulting stool consists of a small cluster of grass-like shoots. Two such stools are illustrated in Fig. 5; it will readily be understood from this photograph of P.O.J. 2714 that each stool is 100 per cent. loss, and that the presence of the disease is a serious matter.

A bulletin (Bulletin No. 4 of the Division of Pathology) dealing fully with the subject of Fiji disease and its transmission, has just been published, and may be had on application to the Director of the Bureau of Sugar Experiment Stations.

Fig. 5.

The two small grass-like stools in the foreground are the result of ratooning diseased stools. The planting of infected cuttings yields a similar type of plant. Variety P.O.J. 2714, 9 months old.

P.O.J. 2878 in the Moreton District.

ON account of the high resistance to gumming disease and comparatively vigorous growth of the variety P.O.J. 2878, steps were taken to propagate this cane in the Moreton district some two years ago, and this year nearly 500 tons will be available for distribution to farmers. Since the elimination of D. 1135 by gumming disease, this district has had great need of a cane which could be allowed to stand over for harvesting at the commencement of the season. It appeared that P.O.J. 2878 might possibly fill this requirement, and accordingly, arrangements were made with Mr. D. McDonald, of Bli Bli, to stand over a small trial block of about one-third of an acre. This cane was

planted late in the 1931 season in one of the poorest parts of Mr. McDonald's farm, and at the conclusion of last season the plot would not have cut out at the rate of 20 tons per acre. The second year's growth has been very satisfactory, and the plot is now estimated to cut at the rate of at least 50 tons per acre. The excellent appearance of the crop is illustrated in Fig. 6.

FIG. 6.—50-TON STANDOVER CROP OF P.O.J. 2878, MARCOCHY RIVER.

It now remains to be seen whether the c.c.s. of this cane (which is normally a late maturing variety) will be satisfactory, and to gain information on this point, the manager of the Moreton Central Mill has kindly agreed to carry out a systematic series of maturity tests.

Should the c.c.s. prove satisfactory at the commencement of the crushing, this variety should be of considerable value as a standover cane, particularly if planted late or on poorer land.

Although P.O.J. 2878 is highly resistant to gumming disease it should again be emphasised that it is highly susceptible to Fiji disease, and it is very doubtful whether it can be grown successfully in the Maryborough and Beenleigh districts. In the Moreton district, reasonable care should serve to avoid the variety becoming infected, and, in particular, the removal of plants from one part of the district to another should be avoided.

Fertilizer for Ratoons.

QUITE recently we were reviewing the results of our farm fertility trials, and in working over the average increases in crop yield due to fertilizer, the following interesting figures were obtained:—

—	Fertilized.	Non Fertilized.
	Tons.	Tons.
Plant Cane	28·4	21·0
First ratoons	23·8	13·5

These results are the average of twenty-six trials, located in all cane areas, which were harvested as both plant and ratoon crop experiments. The striking feature of these results is that, although the average increased yield on plant cane was but 4·6 tons per acre, the ratoon crop showed an increase of 7·5 tons due to fertilizer.

The average yield for fertilized ratoons was 21 tons of cane per acre, as against 13·5 tons where no fertilizer was employed. These figures demonstrate in no uncertain manner the absolute need for fertilizer applications, if ratoon yields are to be maintained at a high level. The above results show, further, that by the use of fertilizer, the yield of first ratoons (21 tons) is but slightly inferior to the average plant crop unfertilized (23·8 tons).

With regard to the *kind* of fertilizer, it should be pointed out that ratoons require the same type of mixed manure as the plant cane; but when top-dressings of sulphate of ammonia are later made, remember that ratoons give marked response to this material. In the Burdekin and far Northern areas, it appears that it is economical to apply as much as 600 lb. per acre of this manure.

Fertilizer gives the best results only when its use is combined with first-class cultivation, and in the irrigated districts with the timely application of irrigation water.

Sugar-cane Quarantine Districts.

THE attention of sugar-cane growers is again directed to the fact that, in order to assist in preventing further spread of cane diseases, the State has been divided into nine quarantine districts. Under the provisions of the Diseases in Plants Acts the transfer of cane plants from one quarantine district to another is prohibited unless a special permit has been issued.

In order to reduce the risks of further spread of Fiji disease, Southern Queensland has been divided into four such quarantine districts as follows:—

1. Bundaberg-Childers.
2. Maryborough-Bauple.
3. Moreton, and
4. Beenleigh.

Any person desiring to send cane from, or bring cane into, these districts during the current season is requested to make application to the Director, Bureau of Sugar Experiment Stations, Brisbane, before 15th July, 1933, in order to enable the necessary inspections of the cane to be made.

Cane Ripening and Maturity Testing.

By H. W. Kerr.

IN the early days of the Queensland sugar industry, the miller purchased the cane from the grower purely on the basis of tonnage supplied. There was, as a consequence, nothing to induce the grower to cultivate canes rich in sugar content, and a heavy-yielding cane was the farmer's friend. As the older canes passed out—chiefly through the agency of disease—and the industry came to appreciate the fact that the ultimate marketable commodity was "sugar" and not "cane," attention was turned to the propagation of only those varieties rich in sugar. The Cane Prices legislation sought to encourage this practice by fixing the scale for distribution of the value of the crops on the basis of its recoverable sugar content. The "standard" c.c.s. value was fixed at 12 per cent., and it was declared further that the *full* value of the sugar in the cane over and above this percentage should go to the grower. This value was determined on an assumed basis of 90 per cent. coefficient of mill work.

The farmer was thus offered a "bonus" to encourage this desirable policy, and its influence may be traced in the progressive improvement in the average c.c.s. content of the Queensland cane crop over the past fifteen years, and "sweet" varieties such as Q. 813, Badila, M. 1900 Seedling, and B. 208 have replaced the old standards—Malabar, Rose Bamboo, and Striped Singapore.

Queensland cane, in fact, enjoys the distinction of being the sweetest in the world. During the past four seasons, the average figure for the tons of cane to make 1 ton of 94 n.t. sugar has been below 7·0, while in 1930 the phenomenally low value of 6·83 was recorded. It must not be claimed, however, that this achievement is entirely due to the efforts of the grower; certainly he has concentrated on the growth of canes

of high sugar content, but the quality of our cane is naturally assisted by the climatic conditions peculiar to the growing season experienced in this country. It is a happy circumstance that our wet season coincides with the period of long, hot summer days; and the winter climate is sufficiently cool and dry to induce a definite check in crop growth, thus assuring a rapid accumulation of sugars to produce highly-concentrated juices. In no other cane country are these favourable conditions so clearly defined. Finally, the marked advances in milling work of recent years have also contributed in no small degree to the improved recovery figure.

FACTORS AFFECTING MATURITY.

The several factors which affect the process of cane ripening have been the subject of extensive study, both here and abroad; and though certain influences have been definitely related to the maturity process, the problem is so highly complex that its exact course is but partially understood.

It has already been pointed out that a growth check due to cold weather is instrumental in "putting density into the cane," as the farmer expresses it. Yet we find that the highest c.c.s. values are recorded, *not* in the southern areas, but in the central and northern districts of the State.

Undoubtedly, the age of the cane is an important consideration—that is, a crop which shows millable cane before December will, in general, attain a higher sugar content in the harvesting season than one which produces the major portion of its cane in the months of March, April, and May. An excellent example of this influence is shown by the low pre-harvest tests recorded with spring plant cane and ratoons in the Northern areas during the present season, which is characterised by vigorous late crop growth. Probably the superior sugar content of a standover crop early in the season is due to this age factor.

Soil type exhibits its own definite influence on the course of maturity, and it is found that light loams and alluvial silts usually produce crops which mature early and show a high sugar content. On the contrary, heavy wet soils make for late maturity, and generally lower sugar values.

The time of fertilizer application has a profound bearing on the maturity process, while the nature of the fertilizer applied is probably equally important. It is well appreciated that heavy dressings of sulphate of ammonia prolong the growing period, and in the case of excessive amounts, the ultimate c.c.s. value attainable at maturity is permanently lowered. On the other hand, potash is regarded as a plant food which hastens maturity, and the evidence available from our Queensland experiments appears to support the view. Certainly, potash fertilizers applied to soils markedly deficient in this plant food result in a definite improvement in the c.c.s. content of the crop, as is well exemplified by our returns from trials on red volcanic loams.

It is well known that the variety is of considerable importance with respect to the period of maturity. Canes such as Clark's Seedling, H.Q. 285, and Mahona are spoken of as "early maturers," as they normally attain their peak of sugar content early in the harvesting season. Other varieties are designated "late maturers," since they do

not ripen until the latter end of the harvest; P.O.J. 2714 and P.O.J. 2878 are good examples of this class. Intermediate stands the class which embraces the majority of our varieties—these "mid-season" canes such as Badila, M. 1900 Seedling, and Q. 813 mature in the months of August, September, and October.

In those areas where canes arrow, this characteristic is generally regarded as a sign of maturity. It is supposed by many farmers that a cane is fully mature about six weeks after arrowing, but it is found that this is quite an unreliable guide. Certainly, a crop which has arrowed cannot make any more growth of stalk, but careful investigations have shown that there is no definite connection between the time of flowering and the period of crop maturity. Arrowing is itself correlated with a series of complex factors which are, in turn, not clearly defined, and these factors are not necessarily closely related to the sugar content of the crop.

It must, therefore, be concluded that there are no general rules which may be followed in determining the exact time of crop maturity; nor is there any definite outward appearance of the crop whereby this condition may be gauged. It is true that, in a general way, the grower may effect a considerable modification in the maturity sequence of his blocks by careful attention to the selection of varieties and modified cultural practices, and those growers who produce their crop under irrigated conditions possess particular advantages in this regard. But if the farmer would achieve his desire of harvesting each block as closely as possible to the peak of maturity, careful and systematic analytical tests on selected samples from each field afford the only satisfactory means.

MATURITY TESTING.

Such a system has been brought prominently before the notice of Queensland canegrowers by the pioneering efforts of the Farleigh mill staff during the past two seasons. The scheme adopted is not a new one, as they have emphasised, but follows closely on the method worked out in Java and practised in that country for a number of years.

The theory underlying the method is briefly as follows:—An examination of selected sticks of cane from a rapidly-growing crop will show that the juice from the lowest internode is richest in sugar, while that from the uppermost end of the stick is almost devoid of sucrose. Intermediate portions of the stick will yield juices which vary in a regular manner between these extremes. As maturity is approached, the bottom portion of the stick attains its maximum sugar content first of all, followed successively by the middle and top sections; and when the crop is definitely ripe, all portions of the stick exhibit approximately the same c.c.s. value. This condition is maintained for a greater or lesser period, which marks the time at which the cane should be harvested for maximum crop values. Any delay will result in a steady —and frequently a rapid—decline in juice quality. This takes place, first of all, in the bottom section of the stick, and spreads to the middle and top portions. The successive sets of conditions are, then—(1) With immature cane the bottom of the stick shows the highest c.c.s., and the top shows the lowest; (2) at maturity, all sections of the stalk show the same c.c.s. value; and (3) when over-mature, the juice from the bottoms is lowest, and from the tops highest, in c.c.s.

An attempt has been made to devise a set of apparatus whereby the farmer may carry out tests on his cane, and thus obtain a record of the progress of maturity of his various blocks. By the method proposed, regular stick samples are taken as outlined above. These are divided into three equal sections, and the juice from the respective samples subjected to test by the use of a graduated spindle. If the tests are carefully performed on properly selected samples, the readings obtained from the spindle may serve as something of a guide to maturity. These readings actually give, not a measure of the *cane sugar* in the juice, but of the *total dissolved substances* present. This embraces the cane sugar, the so-called reducing sugars, and other "impurities." In a general way, as the spindle reading increases with progressive maturity, the proportion of cane sugar increases also, while the proportion of other sugars and impurities diminishes. At maturity, the spindle readings for all three sections of the stick are approximately the same. But this is where the difficulty arises; for with over-maturity, the diminution in the spindle reading does not fall away as rapidly as the deterioration of the juice proceeds, and it has been found that by the time an appreciable reduction in spindle reading is detectable, the c.c.s. value may have diminished by several units.

It is for this reason, chiefly, that the employment of the "spindle" test has been deprecated. Further, the need for special precautions in taking the readings is not always appreciated by the grower; such are the necessity for squeezing from the stick sections a reasonably constant proportion of juice at all times, and the adoption of adequate precautions to ensure that the temperature of the juice is carefully regulated before spindling, so that errors will not creep in to upset the results. Certainly, the errors which arise from these causes may be slight, but the differences between the sectional tests at or near maturity are also so small as to render the strictest accuracy necessary.

If the work is to be undertaken, it should be placed in the hands of operators who are competent to do the job, and who are able, by reason of their more extensive experience, to indicate to the grower the true condition of the blocks with respect to maturity. In a report on this subject, presented to the Sugar Technologists' Conference at Ayr, it was suggested that the entire project of testing all fields in a mill area producing 200,000 tons of cane would amount to only 1d. per ton of cane. This would be off-set by an all-round average c.c.s. increase of 0·03 unit; and results to date from the areas where the project has been tried indicate that an improvement of 0·25 unit is a very modest objective. On last year's sugar price this would result in the distribution of a further £8,000 to growers in a mill area growing 200,000 tons of cane.

While on the question of initiating the project, it is probable that co-operative mills would launch such a scheme when they are able to demonstrate its value to the district; but suppliers to proprietary mills should bear in mind that any improvement in cane values due to increased c.c.s. figures is passed on almost wholly to themselves, and they will, therefore, appreciate the necessity for action on their part, if the project is to be launched under these conditions.

It is not suggested that the adoption of maturity testing would eliminate all the ills of over-maturity or the necessity for harvesting certain immature blocks early in the season. Further, other considerations, such as the moving of portable track from block to block, must

enter to modify the working plan. Again, at a certain season a number of blocks may mature within a brief range of time, and the grower will be called upon to exercise discretion in making his choice. But the knowledge gained will permit of an orderly harvesting system, founded on the true basis of maturity, and if the grower finds that he is able to improve his returns by a modification of farm practice—such as time of manuring or irrigating—or the adoption of a modified proportion of each of his varieties, the way is paved for the attainment of a permanent improvement in net average cane values.

When the crop is damaged to a greater or lesser degree by frosts, drought, or pests, the value of the information gained from maturity testing cannot be over-estimated. It may enable the grower to harvest in such a manner that some financial advantage may be gained from a crop which might otherwise be worthless. From the point of view of diseases of over-maturity, such as red rot and sour rots, maturity test figures would quickly convince growers of the necessity of regulating their planting programme so that excessive proportions of the affected varieties may be avoided.

Considered from all aspects, it should be evident to the grower that maturity testing is worth while, and encouraging evidence of appreciation of this fact is found in the increased number of mills at which the work is being undertaken during the present season. This work is being carried out purely for the grower's benefit, and it is worthy of his whole-hearted support.

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